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(54) Title: IMPROVED METHOD AND ADDITIVE FOR THE VISCOSITY OF CRUDE OIL

(57) Abstract: An improved method for reducing the viscosity of crude oil is described. In particular, an improved method of reducing the viscosity of different types of crude oil over a range of temperatures is demonstrated. This viscosity reduction effect is achieved by introducing additives containing polyvinyl alcohols (PVA) to the crude oil. The resulting dispersion mixture not only shows enhanced mobility, but also facilitates the recovery of the original crude oil.

1 **Improved method and additive for reducing the viscosity**
2 **of crude oil**

3

4 The present invention relates to an improved method and
5 additive for reducing the viscosity of crude oil and in
6 particular to an improved method of reducing the
7 viscosity of different types of crude oil over a range of
8 temperatures.

9

10 Many crude oil deposits are of such high viscosity that
11 they are very difficult to exploit without the aid of
12 chemicals that allow the crude oil to be produced and
13 transported to suitable locations for processing and/or
14 shipping.

15

16 Crude oil (or crude petroleum oil) is found in nature in
17 both surface and subsurface deposits. These deposits
18 contain different oils which have different
19 characteristics. For example, some crude oils contain
20 high levels of waxes, while others contain high levels of
21 naphthenic compounds, among many other organic
22 components. Therefore, viscous petroleum products
23 containing different components are extracted from

1 different oil fields, and the presence of high levels of
2 these components increases the viscosity of crude oils.

3

4 When crude oil is extracted from subterranean reservoirs
5 it is generally at a temperature which allows it to flow
6 either naturally, or with the assistance of pumps, to the
7 surface. In most cases, the temperature of crude oil at
8 the surface is sufficiently high to maintain the low
9 viscosity necessary to allow the crude oil to flow freely
10 from the producing wells to the gathering or production
11 system.

12

13 However, when crude oil is produced and passed through
14 surface pipe-work, it generally loses heat. If the
15 temperature is reduced sufficiently during this process,
16 wax and/or other components precipitate out of the crude
17 oil solution. Alternatively, as a consequence of the
18 temperature reduction, the components reach such a high
19 viscosity that the crude oil flows less readily. In
20 fact, in many cases where viscous crude oils are produced
21 and the temperature is lowered sufficiently, the crude
22 oils will not flow at ambient temperatures.

23

24 Present solutions to the problem of crude oil mobility
25 reduction involve the addition of various different
26 chemicals which increase the mobility and flow
27 characteristics of the crude oil. The choice of
28 chemicals that are used is dependent on whether the
29 precipitation or the viscosity increase mechanism is
30 involved in reducing the mobility of the crude oil.

31

32 When the reduction in flow is caused by wax or asphaltene
33 problems, additives such as inhibitors, pour point

1 reducers, or solvents may be added to increase the flow
2 of the crude oil. These additives either change the
3 composition of the crude oil or interfere with the
4 mechanism of deposition. For example, solvents can
5 change the amount of aromatic components in the crude oil
6 solution or they can interfere with the mechanism of
7 deposition. Whereas inhibitors can prevent precipitation
8 of material from a specific crude oil at a specific
9 temperature and pour point reducers can change the
10 temperature at which crude oil stops flowing when cooled.
11 In general, the effect of these additives is to reduce
12 the viscosity and increase the mobility of the crude oil.
13 However, as alluded to above, it is often necessary to
14 choose a chemical additive that is specific to the type
15 of crude oil and to the mechanism of mobility reduction.

16

17 In the event that specific chemicals are too expensive to
18 use for increasing the mobility of crude oil, a generally
19 applicable system can be used. This system involves
20 using a surfactant and a divalent inorganic ion with a
21 high shear apparatus to form an emulsified system
22 referred to as Orimulsion (for which patents already
23 exist). However, Orimulsions are water in oil emulsions
24 (oil continuous phase) which can prove difficult to
25 separate into oil and water. Such Orimulsions are
26 normally used as fuel rather than being refined to
27 produce more valuable petroleum products.

28

29 Currently, chemicals that are employed to change crude
30 oil flow characteristics are expensive and must be used
31 in large quantities, making the cost of using these
32 chemicals significant. Furthermore, most of the above
33 treatments have the drawback that they are specific to

1 the particular mechanism (precipitation or viscosity
2 increase) by which the crude oil flow properties are
3 decreased.

4

5 From the processes described above, it is apparent that
6 present methods for reducing the viscosity and increasing
7 the flow characteristics of crude oil suffer from several
8 drawbacks and disadvantages.

9

10 It is an object of the present invention to obviate, or
11 at least mitigate, some of the disadvantages associated
12 with the prior art.

13

14 Therefore, it is an object of the present invention to
15 provide a method for reducing the viscosity and
16 increasing the mobility of crude oil.

17

18 It is a further object of the present invention to
19 provide a method and additive for reducing the viscosity
20 and increasing the mobility of crude oil which is not
21 specific to the mechanism of viscosity increase.

22

23 A still further object of the present invention is to
24 provide a method and additive for reducing the viscosity
25 of crude oil which facilitates the recovery of the crude
26 oil.

27

28 According to a first aspect of the invention, there is
29 provided a method for reducing the viscosity of crude oil
30 comprising the step of adding at least one additive to a
31 crude oil, wherein the at least one additive comprises at
32 least one polyvinyl alcohol, and wherein the resultant
33 mixture is a dispersion mixture.

1
2 In the context of the invention, references to viscosity
3 of crude oil should be interpreted to mean viscosity of
4 the crude oil itself and/or viscosity of a mixture in
5 which crude oil is present.

6
7 The method may comprise the additional step of mixing the
8 at least one additive with the crude oil by agitation.

9
10 Preferably, the additive comprises aqueous polyvinyl
11 alcohol.

12
13 The additive may be added by injection.

14
15 Preferably, the method is operated over the temperature
16 range of 10° to 80°. More preferably, the method is
17 operated over the temperature range of 10° to 40°.

18
19 The additive may be added such that it is present in the
20 dispersion mixture in a volume range of 10 %vol/vol to 40
21 %vol/vol as a percentage of the dispersion mixture
22 volume.

23
24 Preferably, the additive is added such that it is present
25 in the dispersion mixture in a volume range of 15
26 %vol/vol to 30 %vol/vol as a percentage of the dispersion
27 mixture volume.

28
29 More preferably, the additive is added such that it is
30 present in the dispersion mixture in a volume range of 20
31 %vol/vol to 25 %vol/vol as a percentage of the dispersion
32 mixture volume.

33

1 The additive may comprise a solution of aqueous polyvinyl
2 alcohol resin with concentration in the range 0.1% to 2%.
3 Preferably, the additive comprises a solution of aqueous
4 polyvinyl alcohol resin with concentration of
5 approximately 0.5%.

6

7 Preferably, the dispersion mixture comprises a continuous
8 aqueous phase and a discontinuous non-aqueous phase.

9

10 The method may comprise the further step of adding a
11 second additive selected to decrease the pour point of
12 the dispersion mixture. Preferably, the second additive
13 is a wax crystal modifier.

14

15 According to the second aspect of the invention, there is
16 provided a method of transporting crude oil from a first
17 location to a second location, the method comprising the
18 steps of:

19 reducing the viscosity of crude oil at the first
20 location by the method according to d in any of
21 Claims 1 to 14;

22 separating the dispersion mixture at the second
23 location.

24

25 Preferably, the dispersion mixture comprises a continuous
26 aqueous phase and a discontinuous non-aqueous phase.

27

28 The method may comprise the further step of separating
29 the aqueous and non-aqueous phases.

30

31 The method may comprise the step of adding a polymer
32 breaker to the dispersion mixture.

33

1 Preferably, the polymer breaker is a periodate salt.

2 More preferably, the polymer breaker is sodium periodate.

3

4 The method may comprise the further step of reforming the
5 dispersion mixture from the separated aqueous and non-
6 aqueous phases by agitating the mixture.

7

8 According to the third aspect of the invention, there is
9 provided an additive for reducing the viscosity of crude
10 oil, the additive comprising at least one polyvinyl
11 alcohol and at least one wax crystal modifier.

12

13 In its fourth aspect, the invention relates to use of at
14 least one polyvinyl alcohol as a viscosity reducing
15 additive in a crude oil mixture.

16

17 According to the fifth aspect of the invention, there is
18 provided a improved system for transporting crude oil
19 from a first location to a second location, the system
20 comprising a conduit having a crude oil mixture flowing
21 therein, wherein the crude oil mixture is a dispersion
22 mixture of crude oil and at least one additive and the at
23 least one additive comprises a polyvinyl alcohol.

24

25 The method for reducing the viscosity of crude oil
26 provides a way of increasing the mobility of crude oil
27 in, for example, pipelines. In achieving this effect,
28 the method produces a "water-wet" oil in water dispersion
29 mixture. In a sense, the dispersion mixture which is
30 formed can be visualised as waxy ball-bearings,
31 surrounded by water.

32

1 Inside a pipeline or conduit, the crude oil forms small
2 globules and (as described above) behaves like waxy ball-
3 bearings inside a water sheath, and the mixture moves
4 freely in the pipeline.

5

6 The method described in the examples uses an aqueous
7 solution of a polyvinyl alcohol (PVA) which is generally,
8 but not necessarily, made at high concentration and
9 diluted. As an alternative, the polyvinyl alcohol can be
10 produced on-site immediately before addition to the crude
11 oil stream.

12

13 The mechanism of adding the additive is by injection into
14 an area of mixing which does not emulsify the aqueous
15 polyvinyl alcohol solution with the crude oil, but
16 produces a dispersion mixture. The dispersion mixture
17 so-formed has a continuous aqueous (or water) phase and a
18 discontinuous non-aqueous (or oil) phase (i.e. an oil in
19 water dispersion). This is not an emulsion, nor does it
20 contain an emulsified phase, rather, it is a dispersion
21 mixture.

22

23 In addition, the aqueous:non-aqueous ratios that are used
24 in the present invention would ordinarily produce a
25 continuous non-aqueous (or oil) phase and a discontinuous
26 aqueous (or water) phase (i.e. a water in oil
27 dispersion). Somewhat surprisingly, this is the opposite
28 of the properties dispersion mixture of the present
29 invention as described above. The dispersion mixture is
30 therefore considered to be "water-wet", as opposed to
31 "oil-wet". Consequently, the present invention allows
32 the aqueous layer to be separated from the non-aqueous
33 layer.

1
2 For each particular crude oil there is an amount of
3 additive which preferentially can be added and which will
4 remain dispersed, and which will not immediately drop out
5 of solution when mixing is stopped. This additive amount
6 is generally between 5% and 25% by volume of the mixture
7 so-made with the specific crude oil.

8

9 The concentration of aqueous polyvinyl alcohol and the
10 shear, or mixing force, required to form the dispersion
11 is dependent on the particular crude oil being treated
12 and the temperature at which the dispersion is made.

13

14 All polyvinyl alcohol materials, irrespective of
15 saponification value, are functional in respect of crude
16 oil viscosity reduction. Therefore, any PVA can be used
17 to reduce the viscosity of crude oil. However, for each
18 particular crude oil there is a PVA with a molecular
19 weight and saponification value which is most effective.
20 Similarly, the concentration at which the additive is
21 effective in an aqueous solution is also crude oil
22 specific. Furthermore, the mixing shear required to
23 create a mixed phase system is particular for the crude
24 oil being treated.

25

26 In certain cases, further improvements maybe made through
27 the addition of wax crystal modifiers to the crude oil
28 before mixing with the additive. Wax crystal modifiers
29 interfere with crystal formation in fluids. In effect,
30 wax crystal modifiers prevent agglomeration within oil
31 globules and thus prevent the formation of precipitates.
32 Therefore, depending on the type of crude oil and desired
33 effect, wax crystal modifiers can act as cold flow

1 improvers, pour point depressants, viscosity reducers,
2 paraffin deposition inhibitors, and the like. A variety
3 of wax crystal modifiers are known in the art, and are
4 generally identified by their function, such as cold flow
5 improver, pour point depressant, viscosity reducer or
6 paraffin deposition inhibitor.

7

8 For example, the dialkylalkenylsuccinates of U.S. Patent
9 No. 2,561,232 (Rudel et. al.), and assigned to Standard
10 Oil Development Company, have been known as effective
11 pour point depressants for petroleum derived liquids
12 since at least as early as 1951. Also, U.S. Patents Nos.
13 3,574,575 and 3,634,052, both of which were assigned to
14 Mobil Corp., and the text, Chemical Additives for Fuels:
15 Developments Since 1978, edited by M.T. Gillies (Noyes
16 Data Corporation 1982), pages 115-152, all of which are
17 incorporated herein by reference, disclose other types of
18 wax crystal modifier.

19

20 Recently, polymer compositions comprising dispersions of
21 at least one olefinically unsaturated compound and
22 containing aliphatic side chains of at least ten carbon
23 atoms (e.g., a polyacrylate or a polyethylene vinyl
24 acetate related product), in a continuous liquid phase
25 comprising at least two surfactants and a liquid polyol
26 was disclosed anonymously in Research Disclosure (July
27 1995), page 501 (entry 37550), as being effective pour
28 point depressants in crude oil (petroleum) and certain
29 fuel oils. These too are suitable for use in combination
30 with the method of the present invention as wax crystal
31 modifiers.

32

1 The method of the present invention overcomes many of the
2 drawbacks associated with the prior art and, in fact,
3 offers several advantages. For example, a transportation
4 system for transporting crude oil that has been treated
5 by the method of the present invention does not require
6 to be heated or thermally insulated keep the viscosity
7 suitably low for the crude oil to be effectively and
8 economically transported.

9

10 The polyvinyl alcohol additive can be rendered
11 ineffective by the addition of a polymer breaker. For
12 example, a polyvinyl alcohol additive dispersed in crude
13 oil is rendered ineffective by being broken by a
14 periodate salt either in solid form or in aqueous
15 solution. After the addition of the polymer breaker, the
16 disrupted polyvinyl alcohol and the water (as the aqueous
17 phase) can be more easily separated from the crude oil
18 (as the non-aqueous phase). The crude oil from this
19 separation has a water content which is sufficiently low
20 that the crude oil can be refined to generate valuable
21 petrochemicals.

22

23 The method as described can confer sufficient stability
24 onto the so-formed dispersion mixture to allow
25 transportation of the crude oil. Also, the dispersion
26 mixture is stable for short periods during which there is
27 cessation of movement within the system.

28

29 In the event that the additive does separate from the
30 dispersion mixture due to excess addition of chemical or
31 prolonged cessation of movement of the crude oil mixture,
32 the dispersion mixture can be reformed by mixing the
33 aqueous and non-aqueous phases, even under low shear

1 conditions, therefore again reducing the viscosity of the
2 crude oil mixture.

3

4 The method described involves the application of an
5 additive which, when added to crude oil, increases the
6 mobility, and decreases the viscosity, of the resulting
7 mixture over a wide range of temperatures. The additive
8 is added to the crude oil in a specific way such that a
9 dispersion mixture, and not an emulsion, is formed.

10 Also, the dispersion mixture formed has a continuous
11 aqueous (or water) phase and a discontinuous non-aqueous
12 (or oil) phase. This method of treating crude oil can be
13 used regardless of the mechanism (precipitation or
14 increased viscosity) by which the mobility of the crude
15 oil is reduced.

16

17 Example embodiments of the present invention will now be
18 described.

19

20 **Example 1**

21

22 A crude oil sample of southern hemisphere origin has a
23 viscosity of less than 1000cP at temperatures above 60°C,
24 which is close to the production temperature for the
25 oilfield from which the crude oil sample has been taken.

26 At this temperature the crude oil is capable of being
27 moved by pumping systems, and is pumped along a pipeline
28 to a suitable production separation facility.

29

30 After entering the production separation system, the
31 crude oil cools and enters the storage system at a
32 temperature of approximately 40°C. The viscosity of the
33 crude oil is now between 2500cP and 5500cP. At this

1 temperature and viscosity, the crude oil cannot be pumped
2 along a pipeline to the shipping point without
3 uneconomically large pumping systems, high pressure
4 pipelines or the provision of a fully thermally
5 insulated, or heated, pipeline.

6

7 By the addition of various amounts of a polyvinyl alcohol
8 solution in water (together with a system capable of
9 dispersing, but not emulsifying, the polymer in the crude
10 oil) the viscosity of the oil is reduced to values of
11 500cP or less, at temperatures of approximately 30°C.

12

13 For the particular crude oil in this example, the amount
14 of additive required is between 20% and 25% of an aqueous
15 solution containing 0.5% of a polyvinyl alcohol which had
16 a viscosity of 50cP at 4% wt/wt in water and
17 saponification degree of 86 mol% to 89 mol%.

18

19 When concentrations of less than 20% of the above 0.5%
20 PVA solution are added, the viscosity reduction is lower,
21 and the viscosity increases with reducing concentrations
22 of additive over the temperature range referred to above.
23 For concentrations higher than 25% the mixture rapidly
24 sheds additive immediately after mixing, and the residual
25 amount of additive dispersed in the crude oil phase
26 stabilises at between 20% and 25%.

27

28 At the optimum concentration addition the resulting
29 dispersion mixture of crude oil and additive is stable
30 for up to 24 hours, and any additive that separates after
31 this time is very easily re-dispersed by simple
32 agitation.

33

1 Table 1 below details the viscosity and the amount of
2 free water present in a dispersion mixture of the
3 polyvinyl alcohol additive and the crude oil sample of
4 the present example at a temperature of 30°C. From the
5 table it is apparent that the viscosity drops rapidly and
6 the percent water content rises markedly with increasing
7 quantities of additive.

8

Additive (%vol/vol)	Crude (%vol/vol)	Temp (°C)	Visc (cP)	Free Water (%)
40	60	30	380	15.5
30	70	30	430	8.1
20	80	30	1080	<2.0
10	90	30	6420	<2.0

9

10 Table 1

11

12 When higher than optimum amounts of additive are added
13 and dispersed in the crude oil, and the resulting mixture
14 is left to stand with no agitation in cylindrical glass
15 vessels at fixed temperature, the water phase sediments
16 within the crude oil column such that the amount of water
17 held in the top of the oil column is lower than that held
18 at the bottom of the column, in addition to that
19 separating out of the oil phase.

20

21 In this example the amount of water present, as
22 determined by coulometric Karl Fischer titration was
23 found to be less than 2% wt/wt at the top of the oil
24 column. The amount of water present at the bottom of the
25 oil column but above the interface of the oil and any
26 separated water was over 20% wt/wt. In this test, the
27 total additive applied was 30% and the volume of

1 separated aqueous phase found at the bottom of the column
 2 after 24 hours was 8%.

3

4 Example 2

5

6 Native crude oil with the viscosities as illustrated in
 7 Table 2 below (two samples from same field, different
 8 wells) contain less than 0.3% wt/wt water as determined
 9 by Coulometric Karl Fischer method.

10

Temperature (°C)	Viscosity (cP)	
	Sample 1	Sample 2
65	1020	553
40	3950	1760
30	12165	4820
25	33230	9820
20	82620	18130

11

Table 2

13

14 After dosing crude oil Sample 1 with additive at 23%
 15 (0.5% polyvinyl alcohol as previously specified above)
 16 and dispersing, the viscosities of the fluid at various
 17 temperatures are as illustrated in Table 3.

18

Temperature (°C)	Viscosity (cP)
40	388
30	491
25	832
20	1863

19

Table 3

20

1
2 In a further experiment, the crude oil Sample 1
3 containing 25% additive dispersion is placed in a beaker
4 with a 20mm stirring bar, in an incubator at fixed
5 temperature of 30°C, and is stirred at 120 rpm using a
6 magnetic stirrer. This simulates the effect of movement
7 of the crude oil in a low flow pipeline situation in
8 which turbulent flow is not present.

9

10 The viscosity of the mixture is measured at various times
11 as illustrated in Table 4 below. All apparatus is
12 enclosed within the incubator to ensure that the
13 temperature remains constant throughout the test period.

14

Time (hours)	Stirring Rate (rpm)	Temperature (°C)	Viscosity (cP)
0	120	30.1	513
0.5	120	30.2	503
1.0	120	30.1	537
5	120	30.1	487
8.5	120	30.2	478
16	120	30.1	551
24	120	30.1	489

15

16

Table 4

17

18 The results show that when the mixture is under constant
19 movement the viscosity deviates little from the initial
20 viscosity measured immediately after creation of the
21 dispersed additive/oil mixture.

22

23 In circumstances where the crude oil and additive
24 dispersive mixture is not constantly under movement, the

1 viscosity of the mixture increases as the aqueous phase
2 sediments to the lower part of the crude oil phase.

3

4 In another experiment, the crude oil Sample 1 containing
5 25% additive dispersion is placed in a beaker in an
6 incubator at fixed temperature. This is done to simulate
7 the effect of no movement of the crude oil in a shut down
8 pipeline situation.

9

10 The viscosity of the mixture is measured at various
11 times. All apparatus is enclosed within the incubator to
12 ensure temperature remains constant throughout the test
13 period.

14

15 The water content of the top of the oil phase is
16 determined by Karl Fischer analysis of samples withdrawn
17 immediately before measurements for viscosity are made.
18 The results from these analyses are illustrated in
19 Table 5.

20

Time (hours)	Water Content (%) Top Oil Phase	Temperature (°C)	Viscosity (cP)	Free Water (mL) Separated)
0	25.8	30.1	528	0
0.5	23.9	30.1	583	0
1.0	22.7	30.2	650	0.2
5	15.4	30.1	1810	0.5
8.5	11.3	30.2	3620	1.3
16	4.8	30.1	7165	3.2
24	2.7	30.1	8030	4.0

21

22

Table 5

1
2 Note that the original crude oil sample, without any
3 additive, had a water content of 0.2%, a viscosity of
4 12165cP, and 0mL of free water at 30.0°C. The viscosity
5 of the mixture, however, never returns to values as high
6 as those found in the original crude oil.

7

8 Example 3

9

10 In another experiment crude oil Sample 1 is mixed with
11 25% additive and agitated at 120 rpm for 24 hrs at 30°C.
12 The viscosity is measured as illustrated in Table 6
13 below, before the addition of 0.1g solid sodium periodate
14 and mixing.

15

Time (hours)	Temperature (°C)	Viscosity (cP)	Free Water (mL) (Separated)
0	30	536	0
0.1	Addition of 0.1% wt/wt sodium periodate		
0.5	30	1165	Trace
1.0	30	2860	3.2
2.5	30	6320	8.1
8.0	30	9170	19.5
16.0	30	10190	22.0

16

17 Table 6

18

19 After 16 hrs the top 75% of the oil column was removed
20 and a water content by coulometric Karl Fischer
21 determination found 3% wt/wt water present in the sample.

22

1 The polymer additive can be removed, or broken, by a
2 polymer breaker. Also, the water content of the crude
3 oil containing additive is reduced by the addition of the
4 polymer breaker and with appropriate mixing.

5

6 As is widely known, the addition of a periodate salt will
7 break 1,2, glycol head to head linkages in a polyvinyl
8 alcohol polymeric material, where these linkages occur.
9 This leads to the formation of lower molecular weight
10 polymer chains which are no longer effective as a crude
11 oil mobility enhancing additive.

12

13 When a crude oil and additive system is dispersed and the
14 resulting mixture is treated by the addition of a sodium
15 periodate salt at a concentration of 0.1% wt/vol, the
16 periodate salt will reduce the polyvinyl alcohol polymer
17 units to a lower molecular weight. The cleaved additive
18 is then no longer able to remain as a dispersed phase and
19 water separates quickly from the crude oil mixture.

20

21 Within a few hours, the aqueous phase sediments to the
22 bottom of the oil column where it separates from the
23 crude oil and can be clearly seen as a distinct, separate
24 aqueous phase.

25

26 **Example 4**

27

28 In this example, tests are performed on a sample of crude
29 oil of European origin with a pour point (the point at
30 which the crude oil solidifies) of 23°C. This material
31 does not respond to treatment with additive in that the
32 crude becomes solid in both the treated and the untreated
33 samples. Pour point measurements are made with various

1 concentrations of **PA082003** wax crystal modifier chemical
2 from Baker Petrolite Limited and also in the presence and
3 absence of 25% volume water containing various
4 concentrations of 1 percent polyvinyl alcohol (PVA)
5 Gohsenol GH 23 (10 % solution of aqueous polyvinyl
6 alcohol resin) from Nippon Gohsei. The pour point is
7 determined by allowing the oil to cool and tilting the
8 container periodically to see if the oil flows. The
9 results from the experiments are shown in Table 7 below.
10 It is apparent from these results that the addition of
11 polyvinyl alcohols markedly decreases the pour point of
12 the crude oil when at least some wax crystal modifier is
13 present.

14

Crude Oil Pour point Readings		
Concentration PA082003 Wax Crystal modifier (mg/kg)	0% PVA (°C)	1.0% PVA (°C)
0	23	23
100	20.5	15
500	20	13
1000	19	11
2000	18	5

15

Table 7

16
17 **Example 5**

18

19 In a further experiment, tests are performed on a second
20 crude oil with a range of different crystal modifiers and
21 polyvinyl alcohol Gohsenol GH23 (10 % solution of aqueous
22 polyvinyl alcohol resin). The chemicals being tested are
23 **A5603C** and **A5445** from Weatherford and **PAO 83110** and the
24 previously tested **PAO82003** from Baker Petrolite. The
25 crude oil is heated to the temperature of interest and

1 the additives are dosed at 20% of a 1% solution of
 2 polyvinyl alcohol and 2000 ppm of wax crystal modifier.
 3 The viscosity of the resultant mixture in centipoise cP
 4 is determined using a Brookfield viscometer. The results
 5 of this experiment are illustrated in Tables 8a to 8e
 6 below. From these results it is shown that the polyvinyl
 7 alcohol additive decreases the viscosity of crude oil
 8 over a range of different temperatures. It is also shown
 9 that wax crystal modifiers can help to enhance the effect
 10 of the polyvinyl alcohol additives.

11

Additive	Viscosity (cP) at Temp.		
	20°C	30°C	40°C
No add	11530	383	270
20% GH-23	3880	207	172

Table 8a

18

Additive	Viscosity (cP) at Temp.		
	20°C	30°C	40°C
A5445	1760	177	140
A5445+GH-23	363	99	39

Table 8b

Additive	Viscosity (cP) at Temp.		
	20°C	30°C	40°C
A5603C	5770	280	120
A5603C+GH-23	486	137	97

Table 8c

21

22

1

Additive	Viscosity (cP) at Temp.		
	20°C	30°C	40°C
PAO82003	5050	307	26
PAO82003+GH- 23	2830	143	38

2

3

Table 8d

4

5 The present invention provides a method for reducing the
6 viscosity and increasing the mobility of different crude
7 oils over a variety of temperatures. Furthermore, the
8 method of the present invention can be used regardless of
9 the mechanism by which the crude oil has become less
10 mobile (precipitation or viscosity increase).

11

12 The present invention also provides a method for
13 transporting crude oil, and a method for transporting
14 crude oil in a pipeline.

15

16 The method of the present invention overcomes many of the
17 drawbacks associated with the prior art and, in fact,
18 offers several advantages. In particular, the present
19 invention does not require the use of large amounts of
20 specific (and expensive) chemical additives for specific
21 type of crude oil. Also, the present method operates
22 over a wide range of useful temperatures.

23

24 Another advantage of the present invention is that the
25 dispersion mixture which is formed is sufficiently stable
26 to allow transportation of the crude oil, and to allow
27 for short periods during which there is cessation of

1 movement within the system. Therefore, the method of
2 transportation of the present invention does not require
3 heating or thermal insulation for the crude oil to be
4 effectively and economically transported.

5

6 In addition, if the additive does separate from the
7 dispersion mixture due to excess addition of chemical or
8 prolonged cessation of movement of the crude oil mixture,
9 the dispersion mixture can be reformed by mixing, even
10 under low shear conditions.

11

12 A further advantage of the present invention is that the
13 crude oil that is recovered from the method has a water
14 content which is sufficiently low that the crude oil can
15 be refined to generate valuable petrochemicals.

16

17 Various modifications may be made to the invention herein
18 described without departing from the scope thereof.

1 Claims

3 1. A method for reducing the viscosity of crude oil
4 comprising the step of adding at least one
5 additive to the crude oil, wherein the at least one
6 additive comprises at least one polyvinyl
7 alcohol, and wherein the resultant mixture is a
8 dispersion mixture.

10 2. The method as claimed in claim 1 comprising the
11 additional step of mixing the at least one
12 additive with the crude oil by agitation.

14 3. The method as claimed in claim 1 or claim 2
15 wherein the additive comprises aqueous polyvinyl
16 alcohol.

18 4. The method as claimed in any of claims 1 to 3
19 wherein the additive is added by injection.

21 5. The method as claimed in any preceding claim
22 wherein the method is operated over the
23 temperature range of 10° to 80°.

25 6. The method as claimed in any preceding claim
26 wherein the method is operated over the
27 temperature range of 10° to 40°.

29 7. The method as claimed in any preceding claim
30 wherein the additive is added such that it is
31 present in the dispersion mixture in a volume
32 range of 10 %vol/vol to 40 %vol/vol as a
33 percentage of the dispersion mixture volume.

1

2 8. The method as claimed in claim 7 wherein the
3 additive is added such that it is present in the
4 dispersion mixture in a volume range of 15
5 %vol/vol to 30 %vol/vol as a percentage of the
6 dispersion mixture volume.

7

8 9. The method as claimed in claim 8 wherein the
9 additive is added such that it is present in the
10 dispersion mixture in a volume range of 20
11 %vol/vol to 25 %vol/vol as a percentage of the
12 dispersion mixture volume.

13

14 10. The method as claimed in any preceding claim
15 wherein the additive comprises a solution of
16 aqueous polyvinyl alcohol resin with concentration
17 in the range 0.1% to 2%.

18

19 11. The method as claimed in claim 10 wherein the
20 additive comprises a solution of aqueous polyvinyl
21 alcohol resin with concentration of approximately
22 0.5%.

23

24 12. The method as claimed in any preceding claim
25 wherein the dispersion mixture comprises a
26 continuous aqueous phase and a discontinuous non-
27 aqueous phase.

28

29 13. The method as claimed in any preceding claim
30 comprising the further step of adding a second
31 additive selected to decrease the pour point of
32 the dispersion mixture.

33

- 1 14. The method as claimed in Claim 13 wherein the
2 second additive is a wax crystal modifier.
3
- 4 15. A method of transporting crude oil from a first
5 location to a second location, the method
6 comprising the steps of:
7 - reducing the viscosity of crude oil at the
8 first location by the method according to d in
9 any of Claims 1 to 14;
10 - separating the dispersion mixture at the second
11 location.
12
- 13 16. The method as claimed in claim 15 wherein the
14 dispersion mixture comprises a continuous aqueous
15 phase and a discontinuous non-aqueous phase.
16
- 17 17. The method as claimed in claim 16 comprising the
18 further step of separating the aqueous and non-
19 aqueous phases.
20
- 21 18. The method as claimed in any of claims 15 to 17
22 including the step of adding a polymer breaker to
23 the dispersion mixture.
24
- 25 19. The method as claimed in claim 18 wherein the
26 polymer breaker is a periodate salt.
27
- 28 20. The method as claimed in claim 19 wherein the
29 polymer breaker is sodium periodate.
30
- 31 21. A method as claimed in Claim 1 to 14 wherein the
32 method comprises the further step of reforming the

1 dispersion mixture from the separated aqueous and
2 non-aqueous phases by agitating the mixture.

3

4 22. An additive for reducing the viscosity of crude
5 oil, the additive comprising at least one
6 polyvinyl alcohol and at least one wax crystal
7 modifier.

8

9 23. Use of at least one polyvinyl alcohol as a
10 viscosity reducing additive in a crude oil
11 mixture.

12

13 24. An improved system for transporting crude oil from
14 a first location to a second location, the system
15 comprising a conduit having a crude oil mixture
16 flowing therein, wherein the crude oil mixture is
17 a dispersion mixture of crude oil and at least one
18 additive and the at least one additive comprises a
19 polyvinyl alcohol.

INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/GB2005/001424

A. CLASSIFICATION OF SUBJECT MATTER	IPC 7 C10M145/04	C10L1/18	C09K3/00	F17D1/17
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C10M C10L C09K F17D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 5 641 433 A (CHIRINOS ET AL) 24 June 1997 (1997-06-24)	1-3, 5-10, 12-17, 21-24
Y	column 2, line 35 - column 3, line 15 column 3, line 50 - line 64 claims	18,19
X	US 3 542 044 A (GERALD D. HANSEN ET AL) 24 November 1970 (1970-11-24) column 1, line 52 - line 66 column 5, line 20 - line 35 claims; table 5	22
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the International filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

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- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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13 July 2005

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Name and mailing address of the ISA European Patent Office, P.B. 5818 Patenlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl. Fax: (+31-70) 340-3016	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB2005/001424

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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